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Some Botanical Laboratories of the United States.

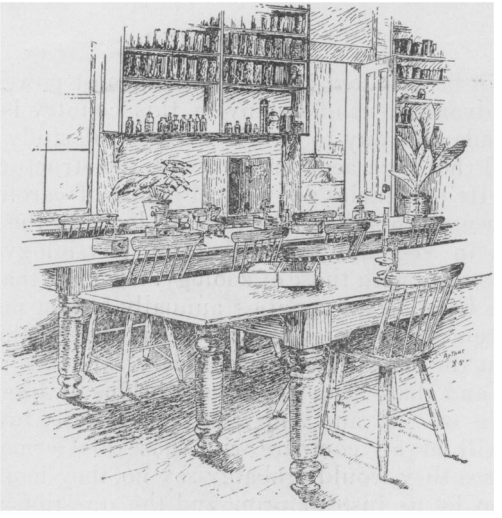
BY J. C. ARTHUR.

It can not be disputed that one of the most powerful auxiliaries to the advancement of botany in this country is the laboratory. It leads the way to a wider range of study and a more intimate and thorough acquaintance with the structure and life of the plant. Its tendencies are toward habits of careful investigation, and through this channel we are to look for the more recondite studies in vegetable anatomy and physiology which will compare favorably with those of zoology. The fact that the laboratories of the German universities annually attract many students of botany from this country shows the interest in this method of study, and at the same time a reactionary influence is evident in stimulating and shaping our own institutions of like nature.

But have we yet any American laboratories worthy of the name that will at all compare with those of Germany? If we ask the masses they would probably say no, they had never heard of any. But let us instead propound the question to the scientific public. I think we may safely take the *American Monthly Microscopical Journal* as a fair representative of this class. Its editor, a year ago, in championing a doubtful hypothesis, asserted in disparagement of his opponents that "comparatively few of the botanists ever use a compound microscope, and of those who do not many are aware of the amount of labor involved in a thorough microscopical investigation my means of thin sections." When this journal made reply by referring the editor to "the every-day experience of our laboratories," he answered that "the amount of scientific investigation in botanical histology that is being conducted in this country is not very great, and we have not a wonderful array of well-equipped botanical laboratories either. It is not our custom to make assertions in these columns that are not sustained by facts of which we are cognizant." But

if the general scientist is so positive and thinks he could marshal facts in his support, let us turn to the several hundred botanists of the country. Even here the majority would likely shake their heads doubtfully as to the value of our laboratories, an anomaly we shall allude to again.

It is the purpose of this article to give a brief account of a few American laboratories in order to demonstrate both their existence and their capacity. The reader can then judge for himself whether we have laboratories that are noteworthy or not. Among the first to be established was that at the Botanic Gardens



LABORATORY AT BOTANIC GARDENS, HARVARD UNIVERSITY, showing door leading to the herbarium.

of Harvard University, which was opened in 1872. This consists of one principal room with east and west light, and two smaller rooms. The lecture room is adjoining, beyond which are the extensive greenhouses. On the other side of the laboratory one passes up a few steps and through a short passage way into the great herbarium, the largest and most valuable one on the continent, beyond which is the fine Gray library. Students can have access to these under certain restrictions. East of the laboratory lies the Botanic Garden, which furnishes abundant material for study, including aquatic and marsh plants. West of the laboratory is the garden of the North American flora, the corner

for sub-alpine plants, plats of grasses, cactus beds, etc. All these are made tributary to the needs of laboratory students.

The laboratory of cryptogamic botany has, after several transfers, been assigned to a large and well equipped room in the Agassiz Museum. Here is an abundance of light, water, instruments and material, and in an adjoining room the special works of reference and exsiccatæ, probably the most complete in the country, and also the library belonging to the Agassiz Museum, to

BOTANICAL LABORATORY FOR ADVANCED WORK AT CORNELL UNIVERSITY.

which the student can have access. This laboratory is shared by one of the instructors in zoology.

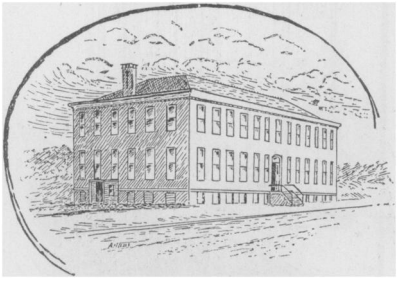
Two years ago provision was made for the main phanerogamic laboratory at College Yard in order to relieve the students of the long walk to the Botanic Gardens. Three rooms of good size in Harvard Hall were plainly furnished but abundantly supplied with instruments and material. There is here an herbarium of New England plants ample for most elementary requirements, and a small library of morphological and physiological works, while

only a short walk across the campus takes one to the main library of Harvard College.

The microscopes used in the Harvard laboratories are Zeiss (1 large stand, 3 No. VI), Verick (12), Leitz (3), Wales (1), Ross (1), and a set of six objectives by Tolles, with plenty of accessory apparatus.

Excellent provision is made for physiological work, for which there is ample supply of ordinary chemical and physical apparatus with such special appliances as micro-spectroscopes, auxanometers, clinostats, thermo-regulators, etc.

The laboratories are in general open three days in the week from nine until five, except for special students who can attend every day except Saturday and Sunday. There can be accommodated at one time in morphological work sixty, in biological course



BIOLOGICAL BUILDING OF UNIVERSITY OF PENNSYLVANIA.

thirty, in histology fourteen, in advanced cryptogamic botany six and in advanced vegetable physiology and systematic botany twelve.

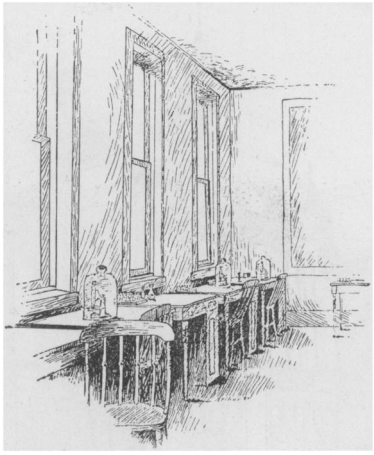
Every facility and encouragement is provided for original research, and the number of teachers of botany who come for study each year gives evidence of the wide appreciation of the opportunities. Taken as a whole the botanical laboratories of Harvard University are the most extensive and important in the country.

The botanical building at Cornell University consists of a main part erected in 1872, 97 by 58 feet, three stories high, which contains what is probably the finest botanical lecture room in America, and an excellent economic and illustrative museum of botany. A two-story extension, 35 by 30 feet was put up in 1882, which with some of the older part is entirely devoted to laboratories. This structure although forming a part of the large build-

ing known as Sage College was built expressly for the botanical department.

The laboratory for analytical and general phanerogamic work is on the second floor, 32 by 22 feet, lighted from three sides and provided with movable tables at which two can sit. Eleven dissecting microscopes are found ample, as students furnish their own lenses for ordinary work. Forty or fifty students can be accommodated here at one time.

The laboratory below, 62 feet long, contains twelve tables supported from the wall, having north light, and with room for mov-



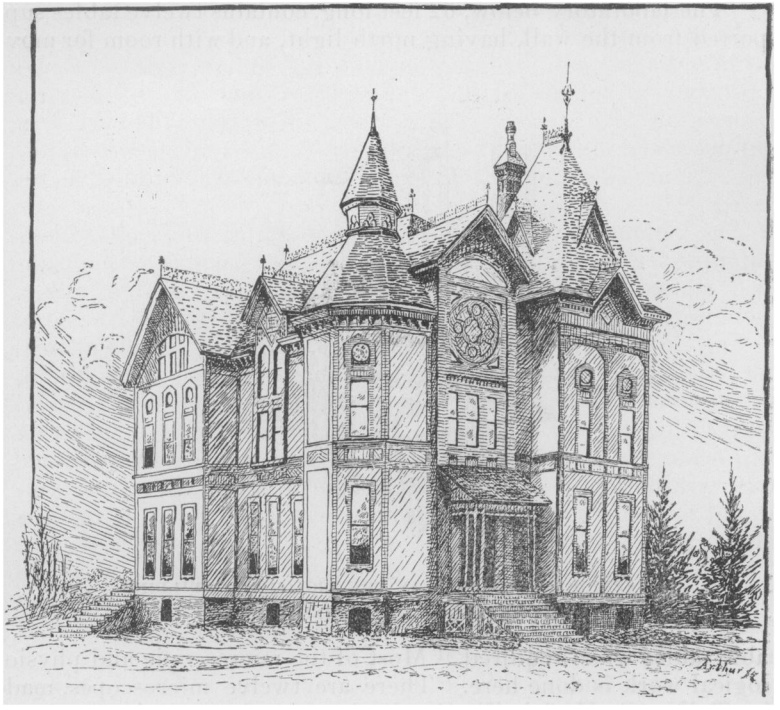
SENIOR LABORATORY IN THE BIOLOGICAL BUILDING OF UNIVERSITY OF PENNSYLVANIA.

able tables when required. Most of the microscopic and physiological work is done here. There are twelve microscopes, made by Tolles (2), Verick (2), Gundlach (1), and the later purchases by Bausch & Lomb. They are mostly fitted with $\frac{3}{4}$ and $\frac{1}{6}$ inch objectives, with additional higher objectives and suitable accessory apparatus.

This room opens directly into the extensive and elegant conservatories which supply abundant material for dissection. The herbarium is ample for the need of students, and is especially full in grasses and sedges. A special aid and incentive to botanical work is the wonderfully rich and varied flora of the immediate vicinity.

The laboratories are open daily except Sunday from eight to five o'clock. Fair facilities are offered for original investigation, especially in microscopic and systematic botany. A bequest which was expected to found an extensive library is now in litigation.

The laboratories of the University of Pennsylvania are in the biological building, erected in 1884. This structure is 84 by 47 feet, two stories high, and a basement. The same rooms are used



BOTANICAL BUILDING OF THE MICHIGAN AGRICULTURAL COLLEGE.

both for zoology and botany. The student first takes a course in general biology with laboratory work in Huxley and Martin's Biology, then Gray's Botanical Text-book accompanied with analytical work, before physiological and anatomical botany is reached.

There are two laboratories, junior and senior, each 30 by 22½ feet, and three of less size, designed for students engaged in special or original work, *all* lighted from the north. Each table is

supplied with a dissecting and a compound microscope, full outfit of chemical appliances, etc., for which the student is held responsible during his connection with the laboratory. Gas is also carried to each table.

Elementary work is done in the laboratory with simple microscopes made by Zentmayer at the request of Professor Rothrock.[1] There are twenty-four compound microscopes, all by Zentmayer. Rooms are open from 9 to 5 o'clock each week day, but on Saturday no one is in attendance.

In the basement are photographic rooms and aquaria. Works of reference are supplied in the building, and the extensive library and herbarium of the Philadelphia Academy of Natural Sciences are also open to the student. For the prosecution of original research, which is specially encouraged, all needed appliances are provided, or if not already in hand are obtained as required.

The laboratory of Illinois University is a room 22 by 28 feet, containing twenty-four tables for one student each, the usual supply of water, gas and shelving, and is exclusively used for botany. There is also the professor's laboratory, in which is the herbarium.

For elementary work with simple magnifiers the student provides his own outfit. The compound microscopes, twenty-one in all, were made by Spencer & Eaton (1), Ross (2), Möller (1), Bullock (1), Nachet (1), Beck (4), Bausch & Lomb (4) and seven were made in the university shops. There are also thermostats, moist chambers, scales, etc. In the same building are good physical and chemical laboratories, from which any needed apparatus may be borrowed.

A greenhouse near the laboratory is tributary to it. The laboratory is open from 8 to 12 and from 1 to 5 o'clock. The present quarters have been occupied since 1876. A special biological building is expected at some future day.

The botanical department of Michigan Agricultural College rejoices in the most imposing building especially erected for botanical instruction in the country. It is a modified Gothic, completed in 1880 at a cost of $6,000. The upper stories contain the botanical museum, very instructively arranged. The laboratory on the first floor, also used as a lecture room, is 48 by 44 feet. It is lighted from east and west, and with ground glass windows on the south. Long tables are placed obliquely at each window, at which a number of workers may sit at a time.

[1] This instrument is described at p. 37, Vol. III, of this journal.

The elementary course, with simple microscopes, permits most of the work to be done outside the laboratory. Coddington lenses with convenient supports are chiefly used. The supply of compound microscopes is at present ample (27), and with funds for the purchase of others as needed. The makers are Zentmayer (1), Sidle (1), Berlis (6), Klein (1), Wales (5), Bullock (1), Bausch & Lomb (11), and one by Ross not now used.

The herbarium and library in the same building are fair size, and meet the needs of undergraduate study. A conservatory and a fine botanic garden, including aquatic plants, a few steps away, and a virgin flora in the vicinity, furnish plenty of excellent material. This laboratory has long been noted for the observant and independent work of its students.

At the University of Michigan a microscopical laboratory was established in 1874 for animal and vegetable histology; since 1879 it has been used exclusively for the latter purpose. Here a large amount of the elementary work is done, much of it being what is known as "microscopy." There are forty-three microscopes, mostly Bausch & Lomb.

The botanical laboratory proper, opened in 1882, occupies a room 40 by 20 feet in the third story of the main building. It is well lighted by eight windows and furnished with movable tables, wall cases, charts, etc. Six Gundlach microscopes with suitable accessories, a small but well selected library containing the works of De Bary, Sachs, Pfeffer, etc., sets of the *Annales des Sciences Naturelles* and *Botanische Zeitung*, are at the service of students. Another room is devoted to the herbarium. The laboratory is open each week day from 8 to half-past 12 o'clock.

A few students each year pursue special investigations, the excellent quality of which is already well known to our readers. The friends of the institution earnestly hope the regents may soon find it feasible to enlarge and more fully equip the department, which has shown itself very worthy of support.

At the Iowa Agricultural College the botanical department has permanent quarters in the second story of North Hall. The laboratory, which was opened about nine years ago and more recently provided for as at present, is 40 by 16 feet and lighted by four north windows. Extending out from each window is a truncated wedge-shaped table, at which two can sit on either side and one at the narrower end furthest from the window. By this arrangement five can comfortably see at each window.

The work with simple magnifiers is mostly done outside the laboratory. There are twenty compound microscopes, partly made

by Schrauer, having Hartnack objectives, but the larger part by Beck, in addition to which is one large binocular by Beck with full complement of objectives and accessories. The laboratory is open four afternoons each week from two to five o'clock.

The herbarium and library occupy an adjacent room. Phanerogams and cryptogams are uniformly arranged and very fully represented, including a large part of the published exsiccatæ. The library is well stocked with standard reference works, both in English and foreign languages.

The new biological building of Wabash College, opened last year, contains two laboratory rooms exclusively for botany. The room for elementary work is 59 by 25 feet, with north, south and east light, fixed and movable tables, an alcove with north light being devoted to work with the compound microscope. For work with simple magnifiers Bausch & Lomb and Beck dissecting instruments are used.

The room for advanced students is 25 feet square, and chiefly lighted from the north. Twenty microscopes are now in use, the manufacturers being Zentmayer (2), Beck (8), McCallister (1), and Bausch & Lomb (9). Some simple physiological apparatus has been provided, and additions to it will be made from time to time. There is a large library especially full in systematic works on phanerogams, and one of the largest phanerogamic herbaria in the west, probably only second to the Engelmann collection. The laboratories are open from nine to four o'clock each week day.

The new arrangements at Wabash College and the liberal attitude of its board of directors, who say that "any book or any material procurable with money will be obtained for original work," give most excellent opportunity for conducting special investigations.

Purdue University opened its laboratory in 1881. It is 40 by 25 feet and furnished with a dozen tables for two workers each. There are twenty-five available microscopes, made by Beck (11), and Bausch & Lomb (14), with an additional set of Beck's objectives up to $\frac{1}{2.0}$ in., and A and E of Zeiss. An equal number of dissecting microscopes, made by Beck (4), and Bausch & Lomb (21) meet the requirement for simple magnifiers. The room is open on Saturday from nine to twelve o'clock, on other week days from nine to four. The future is expected to bring new rooms and additional facilities to this promising beginning.

The laboratories of the University of Wisconsin, established in 1881, are located in rooms intended to answer the purpose for some time to come. Some work in zoology is done in them, while

the zoological laboratories, which were burned not long since, are being rebuilt, otherwise they are exclusively for the botanical department. The main laboratory, 36 by 22 feet, now arranged to accommodate twenty students at a time, is to be doubled in size. The laboratory for advanced and micro-chemical work consists of a suite of rooms covering equal space with the main laboratory. The rooms are open from four to five hours each week day.

Eleven Bausch & Lomb dissecting microscopes are provided for elementary work. There are twenty-five compound microscopes, made by Gundlach (1), Bausch & Lomb (3), Schrauer (2) with Wales objectives, and Leitz (19), also three Abbe condensers, as many homogeneous immersion lenses, an Engelmann microspectroscope and culture apparatus for bacteria investigations. A very good botanical library and phanerogamic and cryptogamic herbarium occupy rooms in the same building. Plant diseases and parasitic fungi are especially well illustrated in both library and herbarium.

The botanical laboratory at the University of Nebraska was first opened in April, 1885, and at present occupies a room, 25 by 18 feet, fitted up to accommodate eight or ten students at a time. It will shortly be removed to rooms in the new Chemical Hall, ample for twenty-one students at once, to be occupied until the large and commodious biological building is erected, which is expected in about two years. The rooms are now open seven hours a day, but it is proposed to reduce this somewhat.

Twenty-five dissecting microscopes and thirty-six Coddington lenses have been provided for elementary work, which is not yet under way. The compound microscopes are by Beck (15), and Bausch & Lomb (6), and in addition one large Beck instrument with a dozen objectives and a full set of accessories. There is already a very fair botanical laboratory and many sets of exsiccatæ.

The last laboratory to be mentioned in this article, that of the Shaw School of Botany at St. Louis, is also the most recent one organized. The formal opening of this new institution occured Nov. 6, 1885. A two-story dwelling house, near the Washington University, of which the school is a department, has been remodeled for laboratory purposes. At some future time a fully equipped laboratory building will be erected, probably at the Shaw gardens. These gardens are very extensive and elaborate, and far exceed those of any other botanical school in the country.

The instruments now ready for use are sixteen Bausch & Lomb dissecting microscopes, one of Zeiss' best stands, with objectives ranging up to $\frac{1}{18}$ homogeneous immersion and full accessories in-

cluding spectroscope, and three Leitz stands with powers ranging to $\frac{1}{16}$ and $\frac{1}{20}$ homogeneous immersion.

The present library consists of the Engelmann library and the pamphlet collection of Dr. Trelease, the professor in charge. The herbarium consists of the large Engelmann collection, the Bernhardi herbarium of perhaps 20,000 species, Riehl's Missouri plants, about 10,000 European plants from the Joad collection, secured through the kindness of Dr. Gray, and the excellent collection of cryptogams of Dr. Trelease. This institution will undoubtedly have unexcelled facilities for post-graduate work and research in the near future.

The foregoing sketch of the botanical laboratories of twelve prominent institutions of learning does not by any means include all there are in the country, but we think sufficiently demonstrates the present condition of American laboratories, and is at any rate as extended as our space permits. Others will be described at some future time.

The laboratory system, in connection with the teaching of botany, may be said to have been introduced in this country about 1870. The next five years saw the beginning of a number of laboratories, usually with limited means and room; but by 1880 their magnitude and importance had sufficiently extended to command the erection of special buildings. Those for Michigan Agricultural College and Cornell University have been designed exclusively for botany; those of the University of Pennsylvania, Iowa Agricultural College and Wabash College are for both botany and zoology; the other institutions named still await the erection of special botanical or biological structures. Harvard University, to be sure, has permanent rooms at the Botanic Gardens, but on account of the distance from the Campus and their limited size, they do not much lessen the need of another special building. In all the twelve institutions, except the University of Pennsylvania and the cryptogamic department of Harvard University, the laboratories described are for the exclusive use of the botanical department, and in all but Michigan Agricultural College the lectures are given in a separate room devoted to that purpose alone.

The number of compound microscopes employed is above twenty on the average for each institution; while the number of students who make use of the laboratories during the year ranges from fifty to one hundred. One can rarely visit any of the laboratories named without finding some original investigation of more or less value in progress, and although the sum total of

such work is not yet large, it is annually increasing and improving in quality.

Our laboratories are now principally devoted to the study of the structure and development of plants; observations are also carried on to some extend upon the habits of plants; but the deeper problems of vegetable physiology are for the most part unprovided for. A point to be borne in mind, at least by those in charge of our principal institutions, is that in the near future there will be a strong demand for adequate laboratory facilities in plant physiology, pathology and bacteriology. These are three great subjects of high scientific and economic importance, and for their best treatment require rooms and apparatus of special design.

If the candid reader has fully read this article, he must acknowledge that there are laboratories in the United States of fair capacity and equipment. Their recent and quiet growth sufficiently explains the general ignorance in regard to them; even among botanists it is for the most part only the younger ones who have felt their direct influence. But such institutions are destined to multiply, and it is confidently expected that at no very distant day botany will be taught by the laboratory method in all our colleges and in many high schools and academies.

1810.—Asa Gray.—1885.

(WITH PLATE XI.)

The eighteenth day of November, 1810, saw the birth of him who was to be the greatest American botanist, and the eighteenth of November, 1885, the seventy-fifth anniversary of that day, brought to him a fitting recognition of his place in the hearts of his fellow-workers.

At a late day it occurred to the editors of the GAZETTE that it would be highly appropriate for botanists to unite in some tribute of love and respect which should commemorate the seventy-fifth anniversary of the birth of ASA GRAY, and should manifest to him somewhat of the admiration and honor in which he is held. Accordingly a letter was sent to all botanists whose addresses could be obtained in the very limited time at our disposal.[1] The responses were prompt and generous. On the 31st of October Messrs. Bigelow, Kennard & Co., of Boston, were

[1] Doubtless many were omitted who would have been glad to join with us. All such omissions must be credited to the absolute necessity for haste.